What is Planetary Protection? NASA, COSPAR, and

The National Academies of

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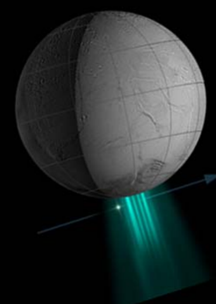
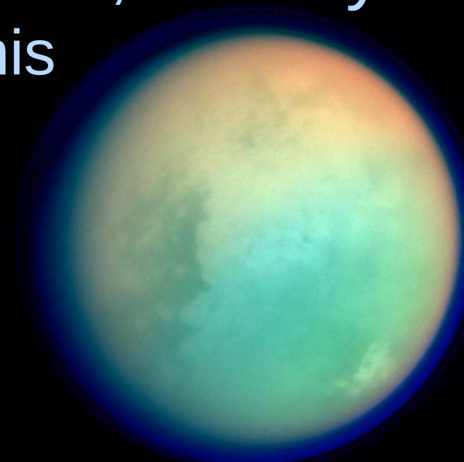
Outline

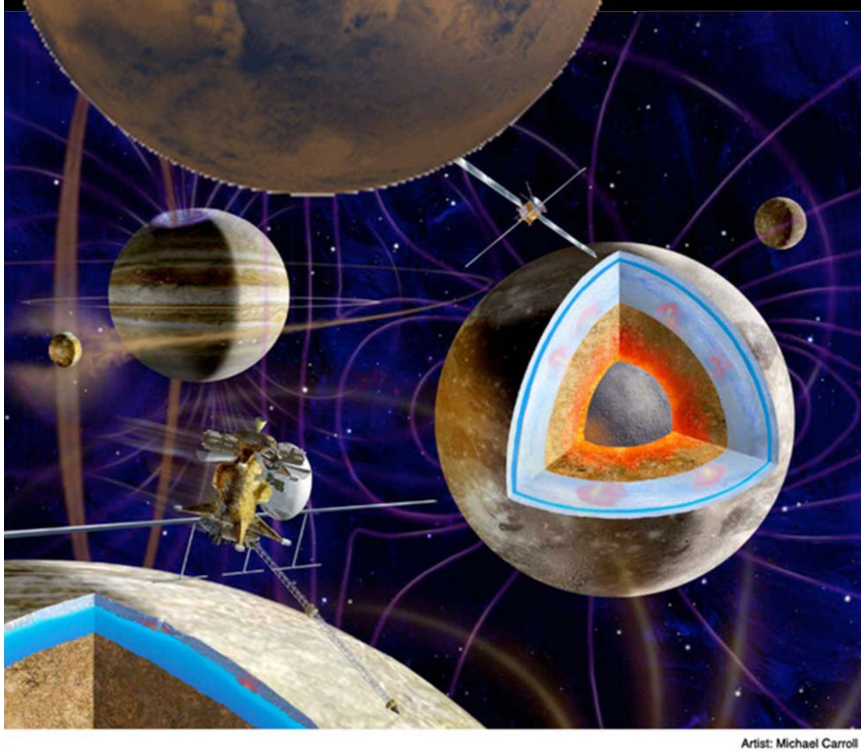
- Current Status
- Early Developments
- Policy Evolution

Protect Hospitable Environments

The unaltered surfaces of most planets are cold, and by being cold, are dry
- spacecraft can change this







Interior environments may be more similar to Earth:
- possible subsurface oceans, both hot and cold
- subsurface rock, similar(?) to inhabited Earth rocks

Planetary Protection Considerations for Robotic and Human Missions

- Avoid contaminating target bodies that could host Earth life (e.g., Mars, Europa, Enceladus)
- Ensure biohazard containment of samples returned to Earth from bodies that could support native life (e.g., Mars and possibly moons, Europa, Enceladus)
- On human missions, characterize and monitor human health status and microbial populations (flight system microbiome) over the mission time, to support recognition of alterations caused by exposure to planetary materials

Earth's Moon,
Most Solar System Bodies

Documentation only;
No operational constraints on *in situ* activities or sample return

Phobos/Deimos

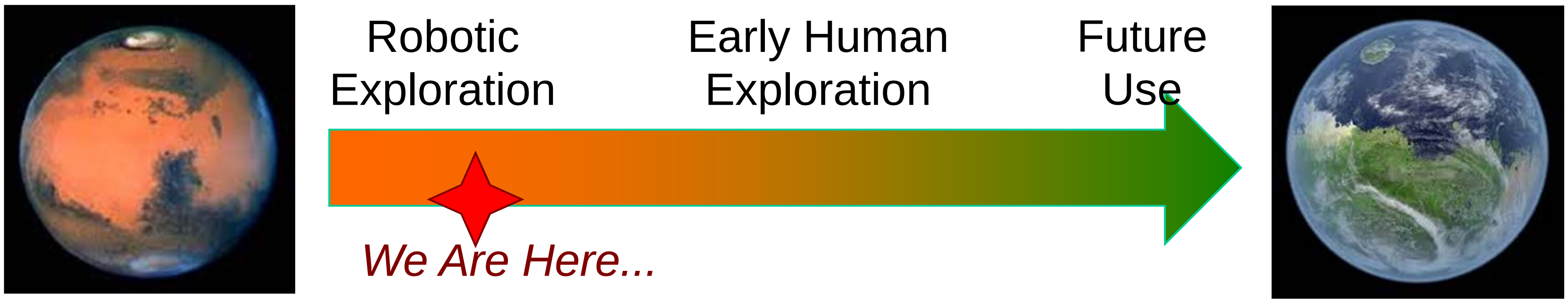
Document *in situ* activities;
Possible return constraints (Phobos requirements currently under study)

Mars, Europa, Enceladus

Documentation and operational restrictions to avoid introducing Earth life;
Strict biohazard containment of returned samples

Example: Protecting Diverse Objectives at Mars

Can be consistent with scientific interests, but with more Earth contamination it becomes more difficult to detect Mars life...



Phased Approach: Be careful early; tailor later constraints to exploration or other goals, using knowledge gained on previous missions

•Humans have many interests at Mars; understanding potential hazards supports all of them

•Searching for Mars life or biohazards becomes more difficult because Earth contamination can overprint biosignatures and reduce signal-to-noise ratios

•Future colonization could be challenged, if unwanted Earth invasive species are introduced

- Blocking aquifers
- Consuming resources
- Interfering with planned introductions

NASA Policy Documents in place: Human mission requirements under development by HEO and SMD

Current International Framework

- The Outer Space Treaty of 1967
  - Proposed to the UN in 1966; Signed in January 1967
  - Ratified by the USSR and US Senate by May 1967
  - Article IX of the Treaty states that:

    "...parties to the Treaty shall pursue studies of outer space including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose..."

- The Committee on Space Research of the International Council for Science maintains an international consensus policy on planetary protection
  - COSPAR policy represents an international scientific consensus, based on advice from national scientific members, including the US Space Studies Board
  - COSPAR is consultative with the UN (through UN COPUOS and the Office of Outer Space Affairs) on measures to avoid contamination and protect the Earth
  - NASA and ESA policies specify that international robotic missions with agency participation must follow COSPAR policy, as a consensus basis for requirements

Elements of Planetary Protection

Compliance

Policy

U.N.

ICSU
International Council for Science

The National Academies of
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Space Studies Board

COSPAR Committee on Space Research

Bureau and Council

<u>NASA PPO:</u>
Oversees compliance with policy, including providing requirements and auditing compliance, with oversight from advisory bodies

<u>NASA Projects/Missions:</u>
Implement requirements to support compliance with policy, using typical project management practices

- US Space Studies Board is US rep to COSPAR and develops recommendations on **policy and requirements**, and forwards to NASA and COSPAR.
- COSPAR public comment and discussion of recommendations facilitated through Panel on Planetary Protection
- Consensus of Panel forwarded to Bureau and Council for review/acceptance

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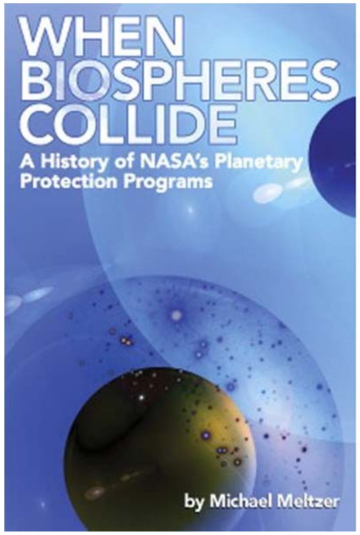
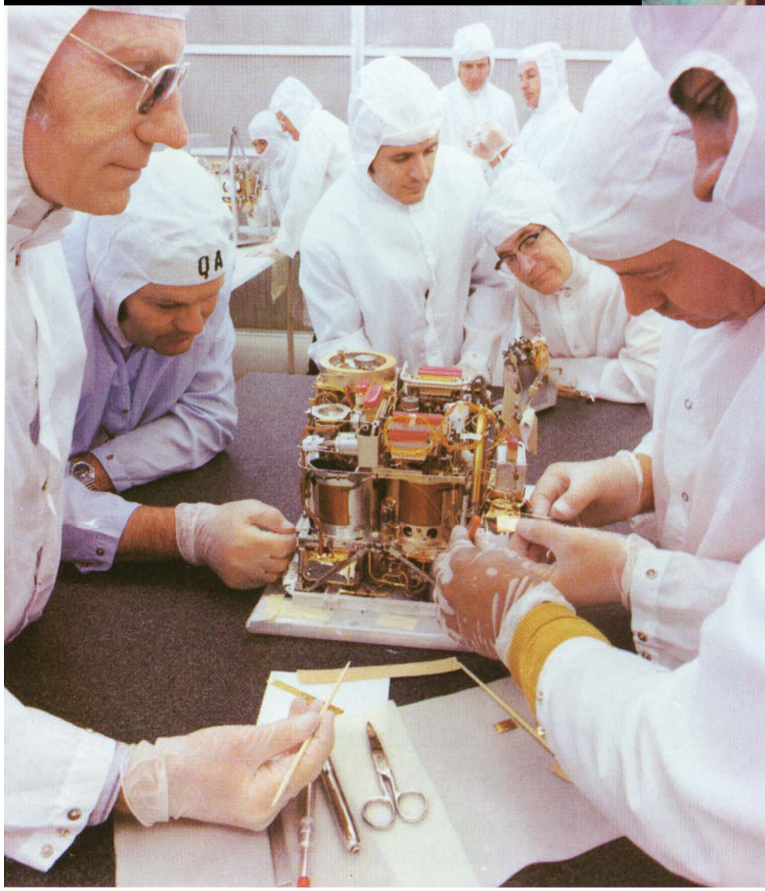
Planetary Protection: Over 50 Years of International Effort

- 1956, Rome: International Astronautical Federation meets to discuss lunar and planetary contamination
- Feb. 1958: International Council for Science (ICSU) forms committee on Contamination by ExtraTerrestrial Exploration (CETEX); NAS Council Resolution on Contamination of Extraterrestrial Bodies
- June 1958: NAS establishes the SSB
- July 1958: Authorization of NASA (Oct. start)
- Oct. 1958: Formation of COSPAR by ICSU
- Dec.1958: Formation of UN-COPUOS
- 1959-1962: Publication of guidelines:
  - US, USSR, COSPAR
- 1963: NASA acquires the first 'Planetary Quarantine Officer' (on loan from the Public Health Service)
  - 1964: COSPAR Resolution 26.5 defines sterilization level in terms of what is needed to produce probabilities for single viable organism on spacecraft (landing or atmospheric penetration <1x10-4 or accidental planetary impact <3x10-5)
- 1969: COSPAR Decision No. 16 estimated probability of <1x10-3 that a planet will be contaminated during the period of biological exploration



1970s: The Inquisition Approach



Viking
Life Detection
Package

Terminal
Sterilization
Works...

1980s: Changes in COSPAR policy post-Viking

- Data from the Viking life-detection experiments were interpreted as a negative result for life detection at Mars
- Other measurements taken at Mars suggested that the planet was much less hospitable to Earth life than previously hypothesized
- Papers by Barengoltz et al., (1981) and DeVincenzi et al., (1983) proposed a 'by exception' mission categorization framework that eliminated probabilistic requirements for all objects unable to host Earth life
- This framework was presented and discussed at a COSPAR Planetary Protection Workshop on 2 July, 1984, and accepted as a COSPAR resolution at the 1984 Colloquium in Graz.

1980s: Changes in COSPAR policy post-Viking

COSPAR INTERNAL DECISION No. 7/84

COSPAR,

- considering that the Workshop on Planetary Protection, meeting on 2 July 1984, has proposed new COSPAR guidelines for planetary protection,
- noting that the commitment to protection of planets from biological contamination must be sustained, and
- noting that planetary protection guidelines must be responsive to current state of knowledge regarding planets,
- decides that existing planetary protection guidelines (1964, 1966) be amended as follows: replace "the basic probability of one in one thousand that a planet of biological interest will be contaminated shall be used as the guiding criterion during the period of biological exploration..." with "for certain space mission/target planet combinations, controls on contamination shall be imposed in accordance with a specified range of requirements ...", in five categories as defined by D.L. DeVincenzi et al., Adv. Space Res., 3(8): 13 (1983).

1990s: SSB Recommends Changes in Policy for Mars

- In 1990 NASA requested that SSB provide an update on Mars planetary protection requirements to reflect the Viking results and modern microbiology
  - Report was delivered in 1992 after thorough study and a workshop
- Report recommended stricter requirements for life-detection missions than for non-life-detection missions
  - Full Viking requirements for the one, Pre-system-sterilization levels for the other
- The report also made several other actions by NASA
  - Viking protocols for assessment of spacecraft bioloads be upgraded to include state-of-the-art methods (but did not recommend equivalence of methods)
  - A sequence of unpiloted missions to Mars be undertaken well in advance of a piloted missions
  - NASA should inform the public about current planetary protection plans and provide continuing updates concerning Mars exploration and sample return
  - Efforts should be made (1) to assess the legal imits (and implied liabilities) in existing legislation that relates to martian exploration and (2) to pursue the establishment of international standards that will safeguard the scientific integrity of research on Mars.
  - NASA should make a strong effort to obtain international agreement for a planetary protection policy.

1990s: SSB Recommendations on NASA Policy

- *Stricter requirements for life-detection missions than for non-life-detection missions, based on Viking requirements*
  - Implemented by COSPAR as COSPAR DECISION No. 1/94, citing DeVincenzi, Stabekis & Barengoltz (1994: Paper F3.5.2).
- *Efforts should be made (1) to assess the legal limits (and implied liabilities) in existing legislation that relates to martian exploration and (2) to pursue the establishment of international standards that will safeguard the scientific integrity of research on Mars.*
- *NASA should make a strong effort to obtain international agreement for a planetary protection policy.*
  - NASA invested in COSPAR continuing as consensus forum for international standards
  - NASA proposed the formation of a Panel on Planetary Protection, which COSPAR effected in 1999
  - NASA proposed a consolidation of various COSPAR decisions on Planetary Protection into a single policy document (first time since 1964), which was accomplished in 2002

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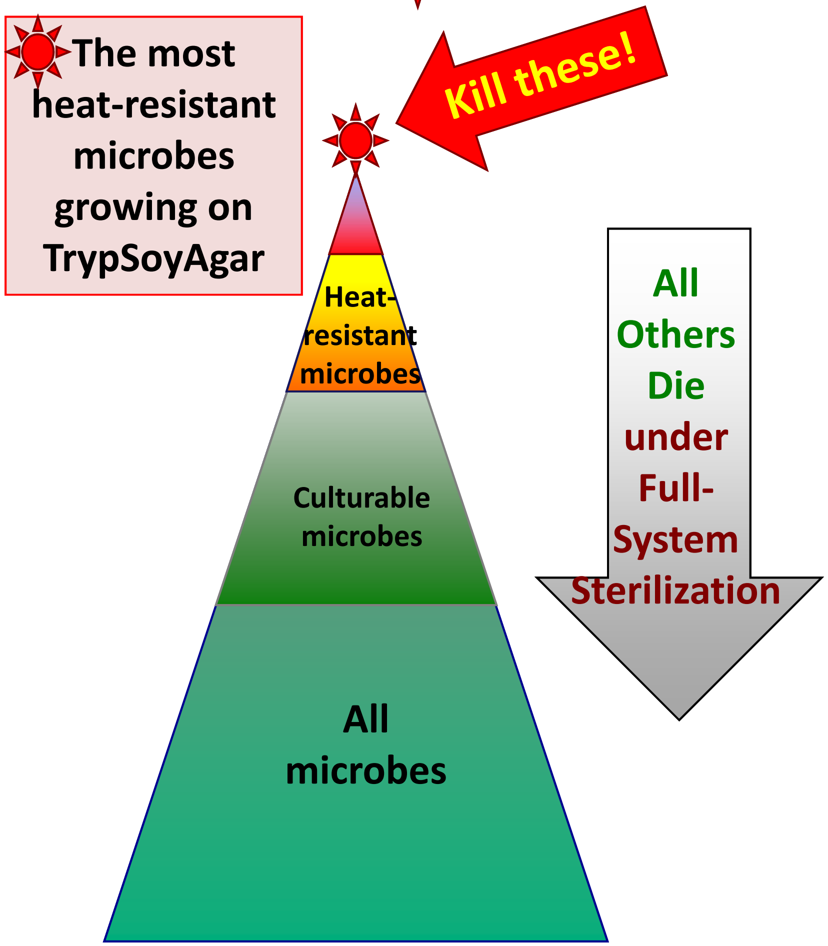
Options for Microbial Reduction

What is a "spore" for planetary protection?



Approximate Cost of Full-System DHMR: One Science Instrument

1970s

Surface Cleaning

Full-System Heat Reduction

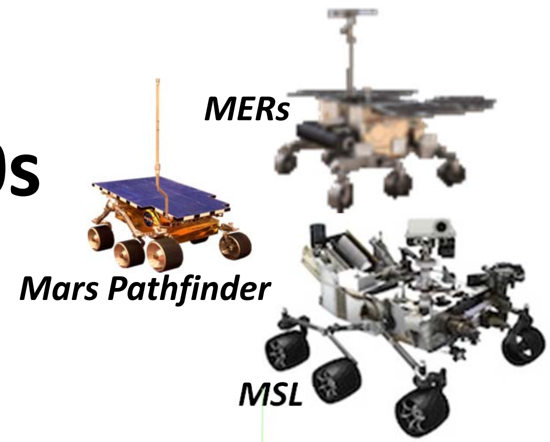
Bioshield during Launch

Organic Cleanliness and Overpressure

Recontamination Prevention for MS

1990-2010s

Surface Cleaning

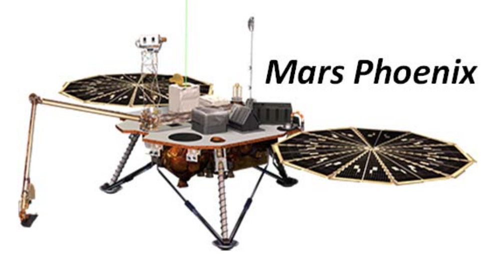


2000s

Surface Cleaning

Subsystem Reduction

Biobarrier for Arm



Category V Restricted Earth Return

NASA/CP—2002–211842

A DRAFT TEST PROTOCOL
FOR DETECTING POSSIBLE BIOHAZARDS IN
MARTIAN SAMPLES RETURNED TO EARTH

Edited by:
John D. Rummel
NASA Headquarters
Margaret S. Race
SETI Institute

- Previous requirements developed over decades of MSR preparation and adopted by COSPAR
- ESA and NASA are continuing a program of requirements refinement
- Key recommendations driving implementation:

  NRC: samples returned from Mars by spacecraft should be contained and treated as though potentially hazardous until proven otherwise

  ESF: a Mars sample should be applied to Risk Group 4 (WHO) a priori

  NRC: No uncontained martian materials ... should be returned to Earth unless sterilized

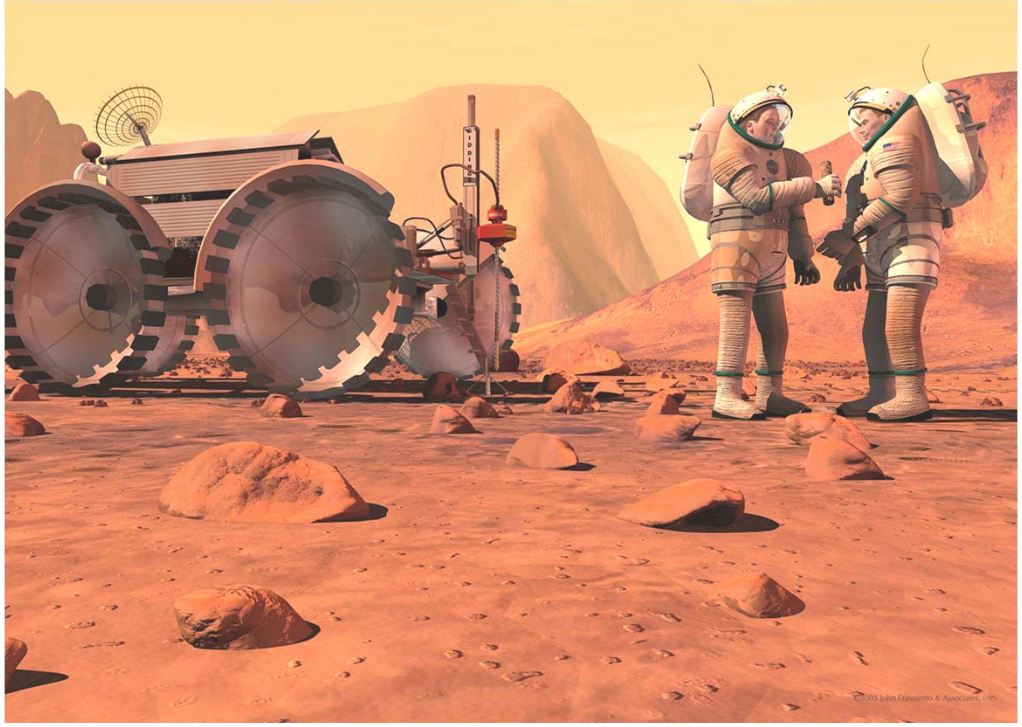
  ESF: the probability of release of a potentially hazardous Mars particle shall be less than one in a million

Apollo-era Restricted Earth Return

Concerns for human missions include both health and safety of the astronauts, and also assuring low risk to the environment of the Earth due to the return of astronauts carrying planetary materials

Development of Guidelines for Human Missions

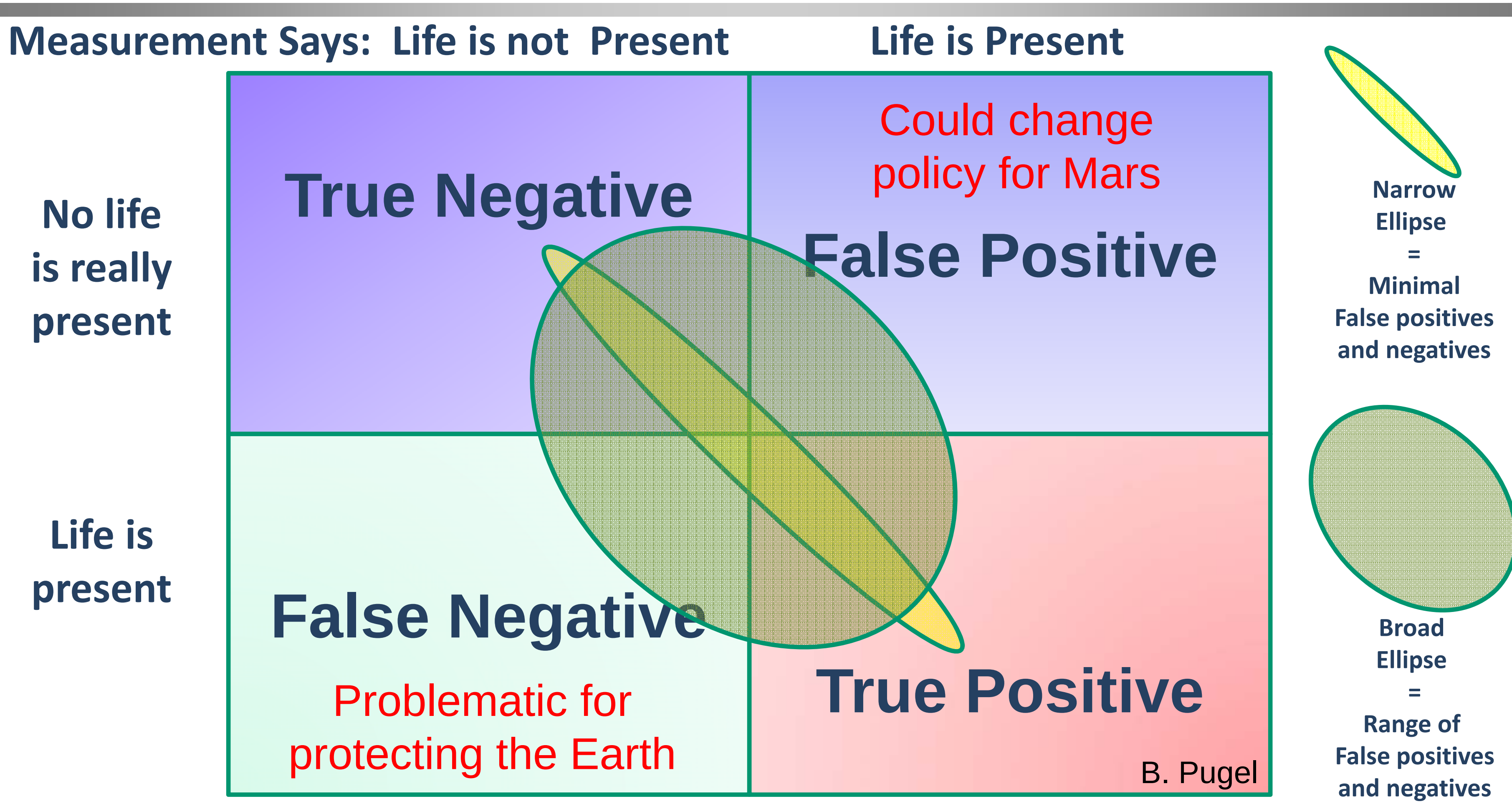
- In June 2001, Human Exploration and Planetary Protection were considered in Pingree Park, Colorado
- In April and May 2005, subsequent workshops were held in Houston, Texas and in Noordwijk, The Netherlands



Key Points:

- It is conceptually possible to develop systems, approaches and operational plans to enable safe, productive human missions in remote, hostile martian environments
- PP will affect design, operations and costs of EVA, life support, environmental health, and scientific systems
- Risk of contamination will be an element of each human mission that can not be avoided, but only characterized, evaluated, and controlled.

Organic Contamination and Life Detection



"NASA should sponsor research on nonliving contaminants of spacecraft ... and their potential to confound scientific investigations or the interpretation of scientific measurements, especially those that involve the search for life."

-- SSB, 2006

Early Policy Concerns Are Still Relevant

- We still do not know if there is native life on any other object in the solar system – but we do know that Earth life has been delivered to every object on which we have landed spacecraft.
- We do not know if possible extraterrestrial life might cause harm to the Earth, or astronauts – but we do know that Earth organisms, if introduced to the wrong places, will cause harm to human objectives.
- Indications of possible extraterrestrial life are not obvious, as we have not found them with the few experiments that might detect something – but we have found indications of Earth contamination. This does not mean that extraterrestrial life is not present: just that we have not been able to detect it yet.
- The worst way to detect extraterrestrial life is after it has been brought back to Earth and released, because we made incorrect assumptions on the basis of incomplete data.

Questions?

Current COSPAR PP Policy References

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